

ABQ12

CALCULATION COVER SHEET



Project:	INEEL V-Tank Remediation Project				Number of Sheets: 1 of 23
Site:	INEEL Test Area North, Idaho Falls, Idaho				
Calculation Number:	ABQ12 – CE008	Work Order Number:	12393.002.001		
Subject:	Water Filtration				
Rev #	Date:	Revision:	Calculated by:	Checked by:	Approved:
RAA	4/31/01	90%	Art Desrosiers	Berg Keshian	
RAB	6/14/01	90%	Art Desrosiers	Berg Keshian	Berg Keshian
RAC	9/28/01	Draft Final	George Prior	Berg Keshian	Daniel Brennecke
RAD	10/22/01	Draft Final Polish	George Prior	Berg Keshian	Jim Lockhart <i>[Signature]</i> 10/24/01

Assumptions:

The loading capacity of granular activated carbon (GAC) was based on published isotherms found in the EPA Tractability Manual, EPA-600/8-80-042a. The quantity of GAC required to remove each compound was calculated and totaled for all compounds to define the total quantity of GAC required. 55-gallon size GAC units will be used with a maximum flow rating of 10 gpm. Two trains with two units in series for each train will be used. Incidental removal of mercury may occur on the GAC, but for purpose of this analysis it was assumed that no mercury removal will occur.

Heavy metals will be removed with ion exchange. The loading will include all cat ions except sodium and hydrogen. Sufficient resin will be provided to treat the water without regeneration. The resin will then be disposed with the heavy metals and radionuclides attached.

Sources of Data:

ABQ03-HP003-RAC

ABQ04-HP004-RAC

GWTF Radionuclide Removal Evaluation (June 17, 1996)

INEL-95/0421 Rev. 0 October 1995

RD/RA WP Appendices H & G – Sampling data for the V Tanks

www.generalcarbon.com

www.usfilter.com

Calculation:

Sample calculations are presented herein to show the methodology used and the results of all calculations are summarized on calculation sheets (Attachment 1) and in the mass balance charts included with the process description in Attachment.

Water treatment from Tank V-1

Volume = 644 gal

TCE level = 0.16 mg/L

$$(644)(10^{-6})(0.16)(8.34) = 8.59(10^{-4}) \text{ lb}$$

Isotherm capacity at 0.01 mg/L = 0.002 lb/lb GAC

$$8.59(10^{-4})/0.002 = 0.43 \text{ lb GAC used}$$

Lead = 0.84 mg/l

CaCO₃ equivalent: 0.84(100/207) = 0.406 mg/l as CaCO₃

Radionuclide Conversion

Mg/L = (pCi/L)*10⁻¹² (Ci/pCi)*10³ (mg/g)/Specific Activity (Ci/g)

$$(1.89E + 04)(10^{-12})(10^3)/6.17E-03 = 0.031 \text{ mg/L}$$

$$\text{Equiv. CaCO}_3 = 0.0031(100/234) = 0.0013 \text{ mg/L}$$

$$\text{U-234} = 1.89E + 04 \text{ pCi/L}$$

Specific Activity = 6.17E-03

Composite for drum filling for Lead

$$\begin{array}{l} V-1: (1040 \text{ gal})(0.84 \text{ mg/L}) = 873.6 \\ V-9: (320)(0.942) = \underline{301.4} \\ \qquad\qquad\qquad 1174.0 \end{array}$$

Total Volume = 3706

$$1174.0/3706 = 0.317 \text{ mg/L}$$

Contingency:

Two trains of GAC units will be operated in parallel to provide added removal of organics in the event that organics in the sludge become soluble during the removal process.

Procedures:

The TOC at the exit of the first bed will be monitored to allow changing beds that are prematurely exhausted. The liquid phase waste will be filtered through oil and grease filters, activated carbon and ion exchanged, then pumped into water HICs. The water will be transferred into a temporary storage tank and sampled for compliance with LDRs. Any additional treatment that is required or desired will be accomplished with a backup treatment system which can be configured with activated carbon and ion exchange, as required.

Conclusion:

This calculation determines the quantity of filtration material required to remove contaminants in the liquid phase of the V-Tanks contents in order to satisfy the land disposal regulations (LDRs) according to the wastewater treatment standard. Since Envirocare cannot accept liquid radioactive waste, the water must be solidified or absorbed prior to shipping for disposal. For conservatism, however, the mass of absorbent is not included in these calculations.

These calculations and the mass balance diagrams included with the process description show all the organic constituents and heavy metals of concern will be significantly reduced below the LDR treatment standards. Furthermore, most of the radionuclides will be removed by the ion exchange resin.

List of Attachments

Attachment 1 Mass Balance Calculations
Attachment 2 Process Flow Diagrams/Mass Balance

Attachment 1
Mass Balance Calculations

SHEET 3 of 12CLIENT/SUBJECT INEEL

W.O. NO. _____

TASK DESCRIPTION _____

TASK NO. _____

PREPARED BY _____ DEPT _____ DATE _____

APPROVED BY _____

MATH CHECK BY _____ DEPT _____ DATE _____

METHOD REV. BY _____ DEPT _____ DATE _____

DEPT _____ DATE _____

Don Exchange for Heavy metalsV-1

Pb	0.84 mg/l	0.406 as CaCO ₃	Using a 3 ft ³ unit (Grainerer 3000 gal) 72 gpm capacity 360 min 71,000 = 12.8 lb as CaCO ₃ 2000 gal 0.002 + 0.002 = 0.004 H2O 16.5 lb Total 16.5 lb
Hg	0.369 "	0.184	
Ca	47.6	119	
Cr	0.4	1.154	
Cu	0.25	0.394	
Fe	12	32.143	
Mg	23.1	95.062	
Mn	2.78	5.054	
Ni	0.529	0.901	
Zn	60.3	92.201	
K	104	246.599 + 33.353	
	say	0.84 mg/l \Rightarrow 1324 lb in 644 gal	
		$380 \text{ min} \Rightarrow 2.04 \text{ lb}$ "	

V-2

Ca	6.49 mg/l	16.23 as CaCO ₃	Radionuclides load: 0.96 as CaCO ₃ \Rightarrow 0.004 lb + 0.004 H2O 16.5 lb Total 16.5 lb
Fe	0.437	1.17	
Mg	? ~3.5	14.58	
Mn	0.776	0.86	
Ni	0.457	0.78	
K	27.6	353.85	
Zn	0.164	0.25	
		387.72	
	say	388 \Rightarrow 1.80 lb \Rightarrow 556	
		\Rightarrow 173 lb in 530 gal	

V-3

Ca	51.4	128.50	Radionuclides 0.25 mg/l \Rightarrow 0.015 + 0.001 lb H2O 16.5 lb Total 16.5 lb
Mg	? ~2.6	108.33	
Mn	8.765	1.39	
Ni	0.185	0.70	
K	51.7	66.28	
Zn	0.964	1.77	
		301.67	
	say	308 \Rightarrow 1797 lb in 6995 gal	

9/27

SHEET 4 of 12CLIENT/SUBJECT 1 NEED W.O. NO. _____

TASK DESCRIPTION _____ TASK NO. _____

PREPARED BY _____ DEPT _____ DATE _____ APPROVED BY _____

MATH CHECK BY _____ DEPT _____ DATE _____

METHOD REV. BY _____ DEPT _____ DATE _____ DEPT _____ DATE _____

		<u>Sludge Drum Filling</u>		
Ba	1.02 mg/l	0.74 for CO ₂	-	0.085 mg/l 2.044 mg/l
Be	0.865	0.72	V-1 1040	0.086 0.067
Cd	1.9	6.69	V-2 1040	0.139 0.117
Cr	90.6	224.50	V-3 1306	W1.12 102.8
Cr	1.46	3.72	V-4 320	0.238 0.687
Co	0.116	0.20	3706	0.010 0.017
Ca	2.98	4.69		0.327 0.515
Fe	17.9	47.95		4.913 13.16
Pb	0.942	0.46		0.317 0.153
Mg	208	860.67		34.59 144.13
Mn	23.5	42.81		3.21 5.84
Hg	0.563	0.28		0.152 0.076
Ni	13.8	23.51		1.194 2.03
K	8340	10,192.31		845.0 1083.
Zn	0.2	27.83		1.888 28.87
		11910.08		1381.526 mg/l as
		say 11,911	⇒ 6.95 lb in 70 gal	70.969 CalCO ₃
				Radiocarbonates 1452.495
				say 1452.5
			Liquid Vol = 1763	⇒ 21.36 lb on CalCO ₃
				in 1.04 lb for Rad
			Total V-1	3.042
			V-2	1.804
			V-3	17.985
			Sludge	21.36
				43.191 lb as CalCO ₃
				Standard Resin = 1.5 kg/ft ³
				⇒ 7 = 2.14 lb/ft ³
				20.287

11/27

SHEET 6 of 12

CLIENT/SUBJECT _____ W.O. NO. _____

TASK DESCRIPTION _____ TASK NO. _____

PREPARED BY _____ DEPT _____ DATE _____ APPROVED BY _____

MATH CHECK BY _____ DEPT _____ DATE _____

METHOD REV. BY _____ DEPT _____ DATE _____ DEPT _____ DATE _____

Compd	Residual mg/l	By/BS GAC	Dept	DATE
1,2-Dichlorobenzene (o-dichlorobenzene)	0.05	0.03	1	0.88 0.47
1,3-Dichlorobenzene (m-dichlorobenzene)	0.03	0.02	1	0.034 0.70
1,4-Dichlorobenzene (p-dichlorobenzene)	0.05	0.03	1	0.09 0.47
3,3-Dichlorobenzidine (Dibenz (e,h) anthracene)	0.05	0.15	1	0.055 0.09
2,4-Dichlorophenol	0.04	0.04	1	0.044 0.23
Diethylphthalate	0.05	0.085	1	0.2 0.16
2,4-Dimethylphenol	0.03	0.02	1	0.036 0.70
Dimethylphthalate	0.04	0.028	1	0.047 0.51
Di-n-butylphthalate	0.05	0.150	1	0.057 0.09
Di-n-octylphthalate	0.01 (etyl)	0.080*	1	0.017 0.18
2,4-Dinitrophenol	0.05	0.02	5	0.12 3.50
2,4-Dinitrotoluene	0.05	0.06	1	0.32 0.23
2,6-Dinitrotoluene	0.05	0.05	1	0.55 0.28
Fluorene	0.05	0.10	1	0.068 0.14
• Fluorene	0.05	0.03	1	0.059 0.47
Hexachlorobenzene	0.05	0.04	1	0.055 0.23
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	0.05	0.05	1	0.055 0.28
Hexachlorocyclopentadiene	0.05	0.20	1	0.057 0.07
Hexachloroethane	0.05	0.02	1	0.056 3.5
Indeno (1,2,3-cd) pyrene	0.005	0.002* (a pyrene)	1	0.0055 7.0
2-Methylphenol (o-cresol)	0.05 0.1	0.03	1	0.11 0.47
4-Methylphenol (p-cresol)	0.05 0.5	0.04	1	0.77 0.35
Naphthalene	0.05	0.03	1	0.059 0.47
2-Nitroaniline (o-nitroaniline)	0.05	0.02*	5	0.27 3.5

RFW 2-Nitroaniline (o-nitroaniline)

32

24.09

12/27



SHEET 7 of 12

CLIENT/SUBJECT _____ W.O. NO. _____

TASK DESCRIPTION _____

PREPARED BY _____ DEPT _____ DATE _____

APPROVED BY _____

MATH CHECK BY _____ DEPT _____ DATE _____

METHOD REV. BY _____ DEPT _____ DATE _____

DEPT _____ DATE _____

Compd	Residual mg/l	DB/GAC	Conc LDR mg/l	mg/l	DB GAC
4-Nitroaniline (p-nitroaniline)	0.02	0.02*	5	0.028	3.15
Nitrobenzene	0.05	0.02	1	0.068	0.70
2-Nitrophenol (o-nitrophenol)	0.02	0.02	1	0.028	0.30
4-Nitrophenol (p-nitrophenol)	0.05	0.03	5	0.12	2.34
N-nitroso-di-n-propylamine (Di-n-propylnitrosamine)	0.05	0.01	1	8.4	0.40
N-nitrosodiphenylamine (Diphenylnitrosamine)	0.05	0.01*	1	3.92	0.40
Pentachlorophenol	0.05	0.04	5	0.089	1.16
Phenanthrene	0.05	0.06	1	0.059	0.23
Phenol	0.03	0.003	1	0.039	0.63
Pyrene	0.05	0.04*	1	0.067	0.35
Pyridine	0.01	0.02*	1	0.014	0.70
1,2,4-Trichlorobenzene	0.05	0.04	1	0.055	0.35
2,4,5-Trichlorophenol	0.05	0.04*	5	0.18	1.16
2,4,6-Trichlorophenol	0.03	0.04	1	0.035	0.35

Correct to water volume = 6.44

$$\frac{6.44}{16.84} (60.75) = 23.23 \text{ mg/l GAC}$$

$$\text{Total mg/l} = 30.02 + 32.00 + 25.15 = 87.15 \rightarrow 0.467 \text{ lb}$$

Estimated TOC of these compds = 0.7(87.15) = 61 mg/l

$$\text{Measured TOC} = 6.6 \quad \text{Adjusted DB.GAC} = \frac{6.6}{6.1}(23.23) = 25.13$$



CLIENT/SUBJECT	W.O. NO. _____		
TASK DESCRIPTION	TASK NO. _____		
PREPARED BY _____	DEPT _____	DATE _____	APPROVED BY _____
MATH CHECK BY _____	DEPT _____	DATE _____	_____
METHOD REV. BY _____	DEPT _____	DATE _____	DEPT _____ DATE _____

Tank V-2 Water Volume treated = 556 gal

Other compounds are present at the same concentrations as tank V-1

Adjusted GAC for Other Compds $\frac{556}{644} (23.23) = 20.06$
lb GAC

TOC due to other compds = 61 mg/l (same as V-1)

Measured TOC = 105

Adjusted GAC for all TOC = $\frac{105}{61} (20.06) = \underline{\underline{34.53 \text{ lb}}}$

Tank V-3 Water Volume Treated = 699.5

As with V-2 Adjusted GAC for other compds $\frac{699.5}{644} (23.23) = 252.32 \text{ lb}$

Adjust for Measured TOC = 105
 $\frac{105}{61} (252.32) = \underline{\underline{434.32 \text{ lb}}}$

Summary:	lb GAC	lb GAC	lb GAC
V-1	0.43	V-2	0.67
	0.30		1.5
	0.40		<u>34.53</u>
	<u>25.13</u>		<u>434.32</u>
	26.16	36.60	453.12

1st Stage GAC consumed after V-1, V-2 and 4100 gal of V-3: $26.16 + 36.60 + \frac{4100}{699.5} (453.12) = 328.35 \text{ lb}$

$453.12 - 265.59 = 187.53 \text{ lb GAC used after changeout}$

14/27

SHEET 8 of 12

CLIENT/SUBJECT _____ W.O. NO. _____

TASK DESCRIPTION: _____ TASK NO. _____

PREPARED BY _____ DEPT _____ DATE _____ APPROVED BY _____

MATH CHECK BY _____ DEPT _____ DATE _____

METHOD REV. BY _____ DEPT _____ DATE _____ DEPT _____ DATE _____

<p>Drum filling - other organics calculate composite concentrations / 16 GAC total volume = V-140 gal, V-104 gal $V-3=306 \text{ gal}$, $V-9=320 \rightarrow 3706 \text{ gal}$, liquid volume = 1763 gal</p> <p>Radiant PBV V-1,2,3 V-9 Campus LDR compound conc molar 66% mg/l mg/l mg/l mg/l 16 GAC</p>					
Aceanaphthalene	0.05	0.30	1	6	1.45 0.059 0.7
Aceanaphthylene	0.05	0.08	1	7	1.53 0.059 0.28
Anthracene	0.05	0.04	1	5	1.36 0.059 0.50
Benz(a)anthracene	0.05	0.02*(k)	1	8	1.62 0.059 1.19
Benz(a)pyrene	0.05	0.007	1	1	1.00 0.061 2.10
Benz(b)fluoranthene	0.05	0.02*(k)	1	7	1.53 0.11 1.12
Benz(g,h,i)perylene	0.005	0.0017	1	3	1.19 0.055 10.29
Benz(k)fluorene	0.05	0.02	1	6	1.45 0.11 1.07
Benzoic acid	1.0	0.05*	5	-	NA -
Benzyl alcohol	0.5	0.02*	1	-	NA -
Bulybenzylphthalate	0.01	0.0045	1	8	1.62 0.017 5.29
Bis(2-chloroethoxy)methane	0.03	0.005*	1	8	1.62 0.036 4.76
Bis(2-chloroethyl)ether	0.03	0.005	1	7	1.53 0.053 4.55
Bis(2-chloroisopropyl)ether	0.25	0.015	1	6	1.45 0.055 1.42
Bis(2-ethylhexyl)phthalate	0.05	0.100	0.083 38	3.36	0.28 0.49
4-Bromophenyl-phenylether	0.05	0.02	1	7	1.53 0.055 1.12
Chrysene	0.05	0.04	(anthrac)	8	1.62 0.059 0.60
4-Chloroaniline (p-chloroaniline)	0.04	0.03*	1	27	3.26 0.46 1.60
4-Chloro-3-Methylphenol (p-chloro-m-cresol)	0.01	0.03*	1	8	1.62 0.018 0.79
2-Chloronaphthalene	0.05	0.05	1	10	1.79 0.055 0.63
2-Chlorophenol	0.04	0.015	1	6	1.45 0.044 1.42
Dibenz(a,h)anthracene	0.05	0.007	1	5	1.36 0.055 2.86
					33.34 42.68

15/27



SHEET 12 of 12

CLIENT/SUBJECT _____ W.O. NO. _____

TASK DESCRIPTION _____ TASK NO. _____

PREPARED BY _____ DEPT _____ DATE _____ APPROVED BY _____

MATH CHECK BY _____ DEPT _____ DATE _____

METHOD REV. BY _____ DEPT _____ DATE _____ DEPT _____ DATE _____

Compound	Residual Conc'n/H	V-2,3	V-9	Compound	LDR	mg/l	GAC
1,2-Dichlorobenzene (o-dichlorobenzene)	0.05	0.05	1 210	1,2-D	0.38	9.34	
1,3-Dichlorobenzene (m-dichlorobenzene)	0.03	0.02	1 6	1,45	0.034	1.07	
1,4-Dichlorobenzene (p-dichlorobenzene)	0.05	0.03	1 49	5.16	0.09	2.53	
-3,5-Dichlorobenzidine (Biphenyl-3,5-dichlorobenzidine)	0.05	0.15	1 66		0.055		
2,4-Dichlorophenol	0.04	0.06	1 8	1.62	0.044	0.40	
Diethylphthalate	0.05	0.05	1 8	1.62	0.2	0.28	
2,4-Dimethylphenol	0.03	0.03	1 79		0.036		
Dimethylphthalate	0.04	0.028	1 7	1.53	0.047	0.80	
Di-n-butylphthalate	0.05	0.150	1 3	1.19	0.057	0.12	
Di-n-octylphthalate	0.01	0.080*	1 6	1.45	0.017	0.27	
2,4-Dinitrophenol	0.05	0.02	5 27	6.97	0.12	5.12	
2,4-Dinitrotoluene	0.05	0.06	1 10	1.79	0.32	0.44	
2,6-Dinitrotoluene	0.05	0.05	1 8	1.62	0.55	0.48	
Fluoranthene	0.05	0.10	1 8	1.62	0.068	0.24	
Fluorene	0.05	0.03	1 5	1.36	0.059	0.67	
Hexachlorobenzene	0.05	0.04	1 7	1.53	0.055	0.37	
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	0.05	0.05	1 10	1.79	0.055	0.53	
Hexachlorocyclopentadiene	0.05	0.20	1 13	2.05	0.057	0.15	
Hexachloroethane	0.05	0.02	1 8	1.62	0.055	1.19	
Indeno(1,2,3- <i>cd</i>)pyrene	0.005	0.002* (approx.)	1 36		0.0055		
2-Methylphenol (o-cresol)	0.25	0.3	1		0.11		
4-Methylphenol (p-cresol)	0.05	0.50*	1		0.77		
Naphthalene	0.05	0.03	1 8	1.62	0.059	0.79	
2-Nitroaniline (o-nitroaniline)	0.05	0.03*	5 6	1.45	0.27	1.07	
				56.50			25.84

16/27



SHEET 10 OF 12

CLIENT/SUBJECT _____

W.O. NO. _____

TASK DESCRIPTION _____

TASK NO. _____

PREPARED BY _____ DEPT _____ DATE _____

APPROVED BY _____

MATH CHECK BY _____ DEPT _____ DATE _____

METHOD REV. BY _____ DEPT _____ DATE _____

DEPT. _____ DATE _____

Comp'd Residual 06/18 GAC V-123 V-9 Comp'd LV 12 mg/l GAC
concn mg/l mg/l mg/l

<u>4-Nitroaniline (p-nitroaniline)</u>	0.02	0.02*	5	4	4.99	0.026	3.67
Nitrobenzene	0.05	0.02	1	9	1.71	0.068	1.26
2-Nitrophenol (o-nitrophenol)	0.02	0.02	1	7	1.53	0.028	1.12
4-Nitrophenol (p-nitrophenol)	0.05	0.03	5	37	7.84	0.12	3.84
N-nitroso-di-n-propylamine (Di-n-propylnitrosamine)	0.05	0.01	1	13	2.05	0.4	3.01
N-nitrosodiphenylamine (Diphenylnitrosamine)	0.05	0.01*	1	13	1.79	0.92	2.63
Pentachlorophenol	0.05	0.04	5	13	5.76	0.89	2.12
Phenanthrene	0.05	0.06	1	6	1.45	0.059	0.36
Phenol	0.05	0.03	1	100	9.66	0.032	-
Pyrene	0.05	0.04*	1	12	1.96	0.067	0.72
Pyridine	0.01	0.02*	1	10	1.79	0.014	1.32
1,2,4-Trichlorobenzene	0.05	0.04	1	7	1.53	0.055	0.56
2,4,5-Trichlorophenol	0.05	0.04*	5	17	6.11	0.18	2.25
2,4,6-Trichlorophenol	0.03	0.04	1	10	1.79	0.035	0.66

~~Total~~
 40.30 Total 23.52
 33.34 p. 8 " 42.68
 56.50 p. 10 " 25.86
 130.14 92.06 lb

Total mg/l of other comp'd = 130.14 mg/l

Estimated TOC of these comp'd = 0.7(130.14) = 91.10

Measured TOC of Composite: 1040(66)+1040(105)+1306(105)+
 320(3) / 3706 = 85 mg/l

Actual concn is at 9 << detection levels off GAC 85 / 130 (92.06) = 60.1988

17/27



SHEET 12 of 12

CLIENT/SUBJECT _____

W.O. NO. _____

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TASK NO. _____

PREPARED BY _____ DEPT _____ DATE _____

APPROVED BY _____

MATH CHECK BY _____ DEPT _____ DATE _____

METHOD REV. BY _____ DEPT _____ DATE _____

DEPT _____ DATE _____

Total CAC Use

Liquid Treat	V-1, 23 (p.1)	22.0
Drum Filling	(p.2)	294.3
TOC	V-1 (p.7)	25.1
TOC	V-2 (p.8)	34.5
TOC	V-3 (p.8)	434.3
TOC Drum Filling	(p.11)	60.2
		<u>870.4</u>
		<u>—</u>

Drum Filling, Oct 6

$$1040(4,17) + 1040(1) + 1306(4,29) + 320(0) = 2,91,161.0$$

$$+ S.S.: 1040(8) + 1040(26,17) + 1306(65,3) + 320(1,6) = 32,9,161.0$$

$$\begin{aligned} \text{Liquid: } & 5,90 \\ \text{Rad: } & 1040(\cancel{2,03} \cdot 10^6) + 1306(3,4,90,10^6) + 1306(1,23,10^6) + 320(4,90 \cdot 10^6) \\ & = 6,70 \cdot 10^6 \\ \text{Cer: } & 1040(2,90 \cdot 10^6) + 1040(135 \cdot 10^6) + 1306(4,23 \cdot 10^6) + 320(0,42 \cdot 10^6) \\ & = 6,13 \cdot 10^6 \end{aligned}$$

Sludge

$$\begin{aligned} \text{Sed: } & 90, 1040(2,703 \cdot 10^6) + 1040(10,91,10^6) + 1306(2,1,62 \cdot 10^6) + 320(6,405 \cdot 10^6) / 3706 \\ & = 18,41 \cdot 10^6 \\ \text{Co: } & 137, 1040(8,806 \cdot 10^6) + 1040(6,192,10^6) + 1306(7,598 \cdot 10^6) + 320(5,590 \cdot 10^6) / 3706 \\ & = 73,69 \cdot 10^6 \end{aligned}$$

18/27

Tank V-1, Preliminary Liquid Phase Radioactive Material

Radionuclide	Activity Detected (pCi/L)	Specific Activity (Ci/g)	Activity Detected (mg/L)	Equiv. CaCO ₃ Concentration (mg/L)
U-234	1.89E+04	6.17E-03	0.003063208	0.001309054
U-235	5.86E+02	2.14E-06	0.284485981	0.112547226
U-238	2.10E+02	3.33E-07	0.630630631	0.264970853
Pu-238	2.24E+02	17.39	1.2881E-08	5.41217E-09
Pu-239	1.05E+02	6.13E-02	1.71289E-06	7.16689E-07
Am-241	1.97E+02	3.24	6.08025E-08	2.52292E-08
Cm-242	U (8.61)	3.32E+03	NA	NA
Cm-243	8.42E+01	46	1.39565E-09	5.74342E-10
Np-237	U (26.7)	7.05E-04	NA	NA
Sr-90	2.03E+06	141	1.43972E-05	1.59968E-05
Ag-108m	U (776)	6.37E+02	NA	NA
Ag-110m	U (1270)	4.66E+03	NA	NA
Am-241	U (1350)	3.24	NA	NA
Ce-144	U (7530)	3.19E+03	NA	NA
Co-58	U (2160)	3.16E+04	NA	NA
Co-60	1.55E+04	1.13E+03	1.37168E-08	2.28614E-08
Cs-134	U (734)	1.30E+03	NA	NA
Cs-137	2.90E+06	87	3.33333E-05	2.43309E-05
Eu-152	U (4860)	1.85E+02	NA	NA
Eu-154	U (1660)	1.45E+02	NA	NA
Eu-155	U (2420)	1.27E+03	NA	NA
Mn-54	U (755)	7.98E+03	NA	NA
Nb-95	U (2400)	3.83E+04	NA	NA
Ra-226	U (1260)	9.88E-01	NA	NA
Ru-103	U (12900)	3.21E+04	NA	NA
Ru-106	U (9430)	3.36E+03	NA	NA
Sb-125	U (3870)	1.06E+03	NA	NA
U-235	U (1340)	2.14E-06	NA	NA
Zn-65	U (1730)	8.20E+03	NA	NA
Zr-95	U (4300)	2.10E+04	NA	NA
I-129	U (252)	1.63E-04	NA	NA
H-3	3.04E+07	9.84E+03	3.15353E-06	0.000105118
Ni-63	2.88E+05	61.7	4.66775E-06	7.40912E-06
		total	0.898237174	0.378980768

*mg/L = (pCi/L)*10⁻¹²(C/pCi)*10³(mg/g)/Specific Activity (Ci/g)*equiv. CaCO₃ was calculated assuming divalent radionuclide

19/27

Tank V-2, Preliminary Liquid Phase Radioactive Material

Radionuclide	Activity Detected (pCi/L)	Specific Activity (Ci/g)	Activity Detected (mg/L)	Equiv. CaCO ₃ Concentration (mg/L)
U-234	3.86E+04	6.17E-03	0.006256078	0.002673538
U-235	1.80E+03	2.14E-06	0.747863551	0.318154703
U-238	4.99E+02	3.33E-07	1.498498498	0.629621218
Pu-238	4.75E+02	17.39	2.73145E-08	1.14767E-08
Pu-239	2.83E+02	6.13E-02	4.61684E-06	1.93165E-06
Am-241	5.89E+01	3.24	1.8179E-08	7.54316E-09
Cm-242	U (4.96)	3.32E+03	NA	NA
Cm-243	1.62E+01	48	3.52174E-10	1.44928E-10
Np-237	U (27.6)	7.05E-04	NA	NA
Sr-90	4.90E+06	141	3.47518E-05	3.86131E-05
Ag-108m	U (3960)	6.37E+02	NA	NA
Ag-110m	U (7120)	4.66E+03	NA	NA
Am-241	U (15900)	3.24	NA	NA
Ce-144	U (37800)	3.19E+03	NA	NA
Co-58	U (1800)	3.18E+04	NA	NA
Co-60	1.30E+04	1.13E+03	1.15044E-08	1.9174E-08
Cs-134	U (764)	1.30E+03	NA	NA
Cs-137	1.35E+07	87	0.000155172	0.000113265
Eu-152	U (4780)	1.85E+02	NA	NA
Eu-154	U (1820)	1.45E+02	NA	NA
Eu-155	U (14400)	1.27E+03	NA	NA
Mn-54	U (716)	7.98E+03	NA	NA
Nb-95	U (1960)	3.93E+04	NA	NA
Ra-226	U (4100)	9.88E-01	NA	NA
Ru-103	U (36000)	3.21E+04	NA	NA
Ru-106	U (46200)	3.38E+03	NA	NA
Sb-125	U (18400)	1.06E+03	NA	NA
U-235	U (6450)	2.14E-06	NA	NA
Zn-65	U (1700)	8.20E+03	NA	NA
Zr-95	U (3210)	2.10E+04	NA	NA
I-129	U (169)	1.63E-04	NA	NA
H-3	1.02E+08	9.64E+03	1.05809E-05	0.000352697
NI-63	4.48E+05	61.7	7.26094E-06	1.15253E-05
		total	2.252630568	0.950967528

*mg/L = (pCi/L)*10⁻¹²(C_i/pCi)*10³(mg/g)/Specific Activity (Ci/g)*equiv. CaCO₃ was calculated assuming divalent radionuclide

20/27

Tank V-3, Preliminary Liquid Phase Radioactive Material

Radionuclide	Activity Detected (pCi/L)	Specific Activity (Ci/g)	Activity Detected (mg/L)	Equiv. CaCO ₃ Concentration (mg/L)
U-234	1.33E+04	6.17E-03	0.002155592	0.000921193
U-235	4.01E+02	2.14E-06	0.167383178	0.079737522
U-238	1.35E+02	3.33E-07	0.405405405	0.170338406
Pu-238	3.83E+01	17.39	2.20242E-09	9.25385E-10
Pu-239	1.97E+01	6.13E-02	3.2137E-07	1.34465E-07
Am-241	3.18E+01	3.24	9.81481E-09	4.07254E-08
Cm-242	U (6.18)	3.32E+03	NA	NA
Cm-243	U (6.28)	46	NA	NA
Np-237	U (36.4)	7.05E-04	NA	NA
Sr-90	1.23E+07	141	8.7234E-05	9.69267E-05
Ag-108m	U (343)	6.37E+02	NA	NA
Ag-110m	U (906)	4.66E+03	NA	NA
Am-241	U (1780)	3.24	NA	NA
Ce-144	U (3000)	3.19E+03	NA	NA
Co-58	U (284)	3.16E+04	NA	NA
Co-60	1.48E+04	1.13E+03	1.30973E-08	2.18289E-08
Cs-134	4.49E+02	1.30E+03	NA	NA
Cs-137	4.23E+06	87	4.86207E-05	3.54898E-05
Eu-152	U (893)	1.85E+02	NA	NA
Eu-154	U (213)	1.45E+02	NA	NA
Eu-155	U (1170)	1.27E+03	NA	NA
Mn-54	U (106)	7.98E+03	NA	NA
Nb-95	U (319)	3.93E+04	NA	NA
Ra-226	U (332)	9.88E-01	NA	NA
Ru-103	U (5640)	3.21E+04	NA	NA
Ru-106	U (4080)	3.36E+03	NA	NA
Sb-125	U (1900)	1.06E+03	NA	NA
U-235	U (533)	2.14E-06	NA	NA
Zn-65	U (237)	8.20E+03	NA	NA
Zr-95	U (549)	2.10E+04	NA	NA
I-129	U (108)	1.63E-04	NA	NA
H-3	6.09E+06	9.64E+03	6.31743E-07	2.10581E-05
Ni-63	2.05E+05	61.7	3.32253E-06	5.27385E-06
	total		0.59508433	0.25115603

*mg/L = (pCi/L)*10⁻¹²(C/pCi)*10³(mg/g)/Specific Activity (Ci/g)*equiv. CaCO₃ was calculated assuming divalent radionuclide

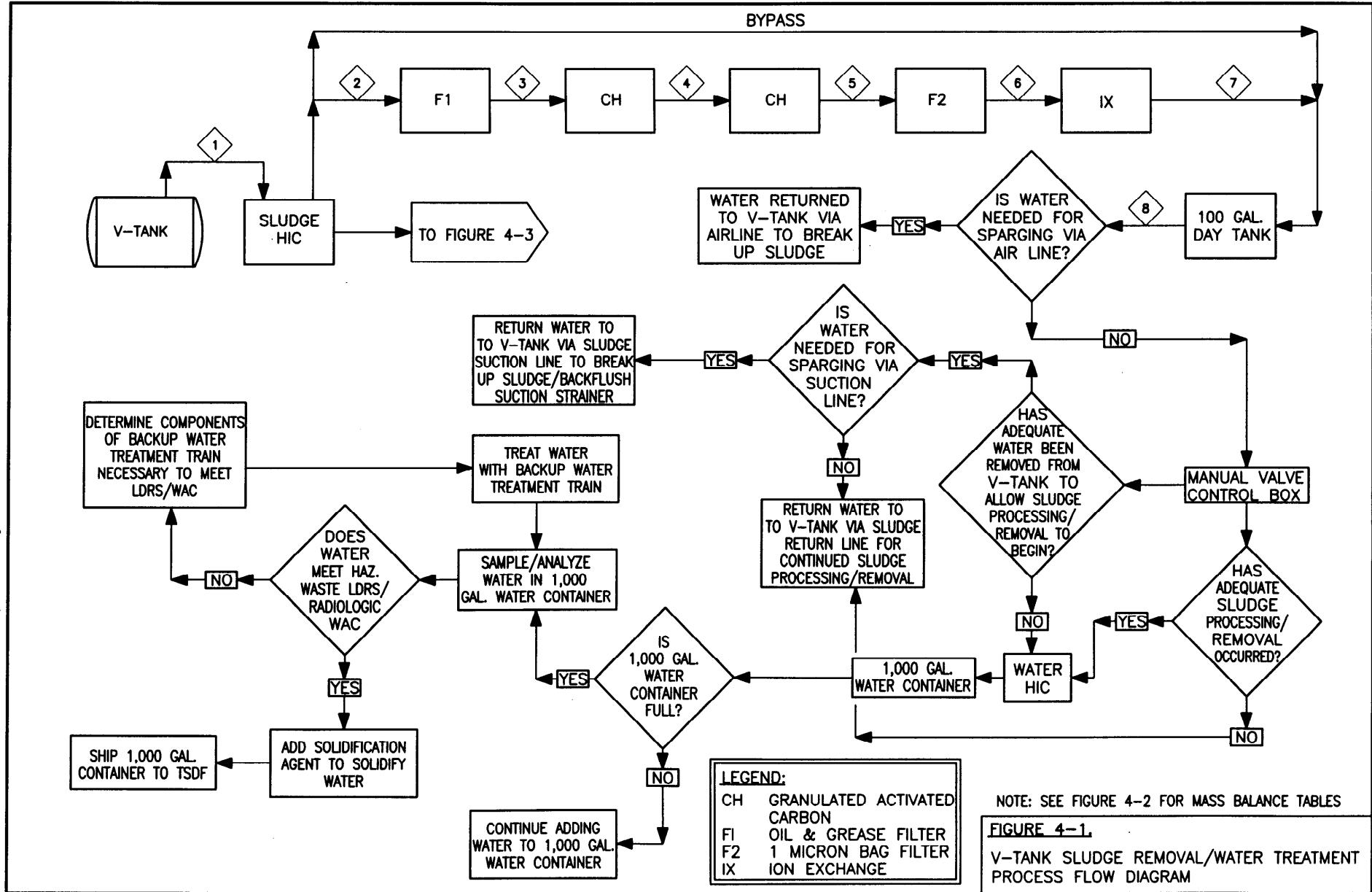
21/27

Tank V-9, Preliminary Liquid Phase Radioactive Material

Radionuclide	Activity Detected (pCi/L)	Specific Activity (Ci/g)	Activity Detected (mg/L)	Equiv. CaCO ₃ Concentration (mg/L)
U-233	1.24E+04	6.17E-03	0.00201005	0.000862683
U-234	2.11E+05	6.17E-03	0.034197731	0.014614415
U-235	6.90E+03	2.14E-08	3.224299065	1.372042155
U-236	3.26E+03	3.33E-07	9.78978979	4.148216013
U-238	9.72E+02	3.33E-07	2.918918919	1.226438521
Pu-238	1.70E+05	6.13E-02	0.002773246	0.00116523
Pu-239	4.53E+04	6.13E-02	0.000738989	0.0003092
Am-241	4.02E+04	3.24	1.24074E-05	5.1483E-06
H-3	3.53E+08	9.64E+03	3.68183E-05	0.001220609
Cm-244	5.21E+03	46.1062	1.13E-07	4.63115E-08
Np-237	2.00E+02	7.05E-04	0.000283688	0.0001197
Total Sr	4.90E+06	141	3.47518E-05	3.86131E-05
Co-60	1.18E+03	1.13E+03	1.04425E-09	1.74041E-09
Cs-137	4.20E+05	87	4.82759E-06	3.52379E-06
Eu-152	5.66E+02	1.85E+02	3.05946E-09	2.0128E-09
Eu-154	2.72E+02	1.45E+02	1.87586E-09	1.21809E-09
		total	15.97109015	6.764171178

^amg/L = (pCi/L)^a10⁻¹²(Ci/pCi)^a10³(mg/g)/Specific Activity (Ci/g)^bequiv. CaCO₃ was calculated assuming divalent radionuclide

Attachment 2
Process Flow Diagrams/Mass Balance



TANK V-1 MASS BALANCE									
STREAM NO.	1	2	3	4	5	6	7	8	LDR WASTEWATER TREATMENT STANDARD
STREAM DESCRIPTION	SLUDGE HIC INFLOW	F1	CH FEED	CH FEED	F2 FEED	IX FEED	DAY TANK	EFFLUENT	
FLOW RATE GPM	10	10	10	10	10	10	10	10	-
VOLUME GAL	1684	644	644	644	644	644	644	644	-
LEAD mg/L	0.84	0.84	0.84	0.84	0.84	0.84	0.04	0.04	0.69
MERCURY mg/L	0.369	0.369	0.369	0.369	0.369	0.369	0.018	0.018	0.15
TETRACHLOROETHENE mg/L	0.14	0.14	0.14	0.02	< 0.01	< 0.01	< 0.01	< 0.01	0.056
TRICHLOROETHENE mg/L	0.16	0.16	0.16	0.02	< 0.01	< 0.01	< 0.01	< 0.01	0.054
TOC mg/L	66	66	66	3	< 0.3	< 0.3	< 0.3	< 0.3	VARIABLES
Sr-90 pCi/L	7.708 E + 06	2.03 E + 06	2.03 E + 06	2.03 E + 06	2.03 E + 06	2.03 E + 06	2.03 E + 05	2.03 E + 05	-
Cs-137 pCi/L	8.806 E + 06	2.90 E + 06	2.90 E + 06	2.90 E + 06	2.90 E + 06	2.90 E + 05	2.90 E + 05	2.90 E + 05	-
OIL & GREASE mg/L	4.17	4.17	1.00	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	-
TOTAL SUSPENDED SOLIDS mg/L	-	8	1	< 1	< 1	< 1	< 1	< 1	-
SPECIFIC GRAVITY	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-

TANK V-2 MASS BALANCE									
STREAM NO.	1	2	3	4	5	6	7	8	LDR WASTEWATER TREATMENT STANDARD
STREAM DESCRIPTION	SLUDGE HIC INFLOW	F1	CH FEED	CH FEED	F2 FEED	IX FEED	DAY TANK	EFFLUENT	
FLOW RATE GPM	10	10	10	10	10	10	10	10	-
VOLUME GAL	1596	556	556	556	556	556	556	556	-
TRICHLOROETHENE mg/L	0.30	0.30	0.30	0.02	< 0.01	< 0.01	< 0.01	< 0.01	0.054
TOC mg/L	105	105	105	5	< 0.5	< 0.5	< 0.5	< 0.5	VARIABLES
Sr-90 pCi/L	1.096 E + 07	4.90 E + 06	4.90 E + 05	4.90 E + 05	-				
Cs-137 pCi/L	6.192 E + 06	1.35 E + 07	1.35 E + 06	1.35 E + 06	-				
OIL & GREASE mg/L	< 1	< 1	< 1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	-
TOTAL SUSPENDED SOLIDS mg/L	-	26.7	1	< 1	< 1	< 1	< 1	< 1	-
SPECIFIC GRAVITY	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

TANK V-3 MASS BALANCE									
STREAM NO.	1	2	3	4	5	6	7	8	LDR WASTEWATER TREATMENT STANDARD
STREAM DESCRIPTION	SLUDGE HIC INFLOW	F1	CH FEED	CH FEED	F2 FEED	IX FEED	DAY TANK	EFFLUENT	
FLOW RATE GPM	10	10	10	10	10	10	10	10	-
VOLUME GAL	8301	6995	6995	6995	6995	6995	6995	6995	-
TRICHLOROETHENE mg/L	0.20	0.20	0.20	0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.054
TOC mg/L	105	105	105	5	< 0.5	< 0.5	< 0.5	< 0.5	VARIABLES
Sr-90 pCi/L	2.162 E + 07	1.23 E + 07	1.23 E + 07	1.23 E + 07	1.23 E + 07	1.23 E + 07	1.23 E + 06	1.23 E + 06	-
Cs-137 pCi/L	7.598 E + 06	4.23 E + 06	4.23 E + 06	4.23 E + 06	4.23 E + 06	4.23 E + 06	4.23 E + 05	4.23 E + 05	-
OIL & GREASE mg/L	4.29	4.29	1.00	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	-
TOTAL SUSPENDED SOLIDS mg/L	-	65.3	5	< 1	< 1	< 1	< 1	< 1	-
SPECIFIC GRAVITY	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-

TANK V-9 CONCENTRATIONS	
STREAM NO.	1
STREAM DESCRIPTION	SLUDGE HIC INFLOW
FLOW RATE GPM	40
VOLUME GAL	320
CADMIUM mg/L	1.9
MERCURY mg/L	0.563
LEAD mg/L	0.942
NICKEL mg/L	13.8
METHYLENE CHLORIDE mg/L	59.0
1, 1, 1-TRICHLOROETHANE mg/L	58.0
TRICHLOROETHENE mg/L	41.0
3, 3-DICHLOROBENZIDINE mg/L	0.066
2, 4-DIMETHYLPHENOL mg/L	0.079
INDENO (1,2-CD) PYRENE mg/L	0.036
2-METHYLPHENOL mg/L	0.83
4-METHYLPHENOL mg/L	0.83
PHENOL mg/L	0.1
TOC mg/L	3
Sr-90 pCi/L	6.405 E + 06
Cs-137 pCi/L	5.590 E + 06
OIL & GREASE mg/L	-
TOTAL SUSPENDED SOLIDS mg/L	-
SPECIFIC GRAVITY	1.02

LEGEND:

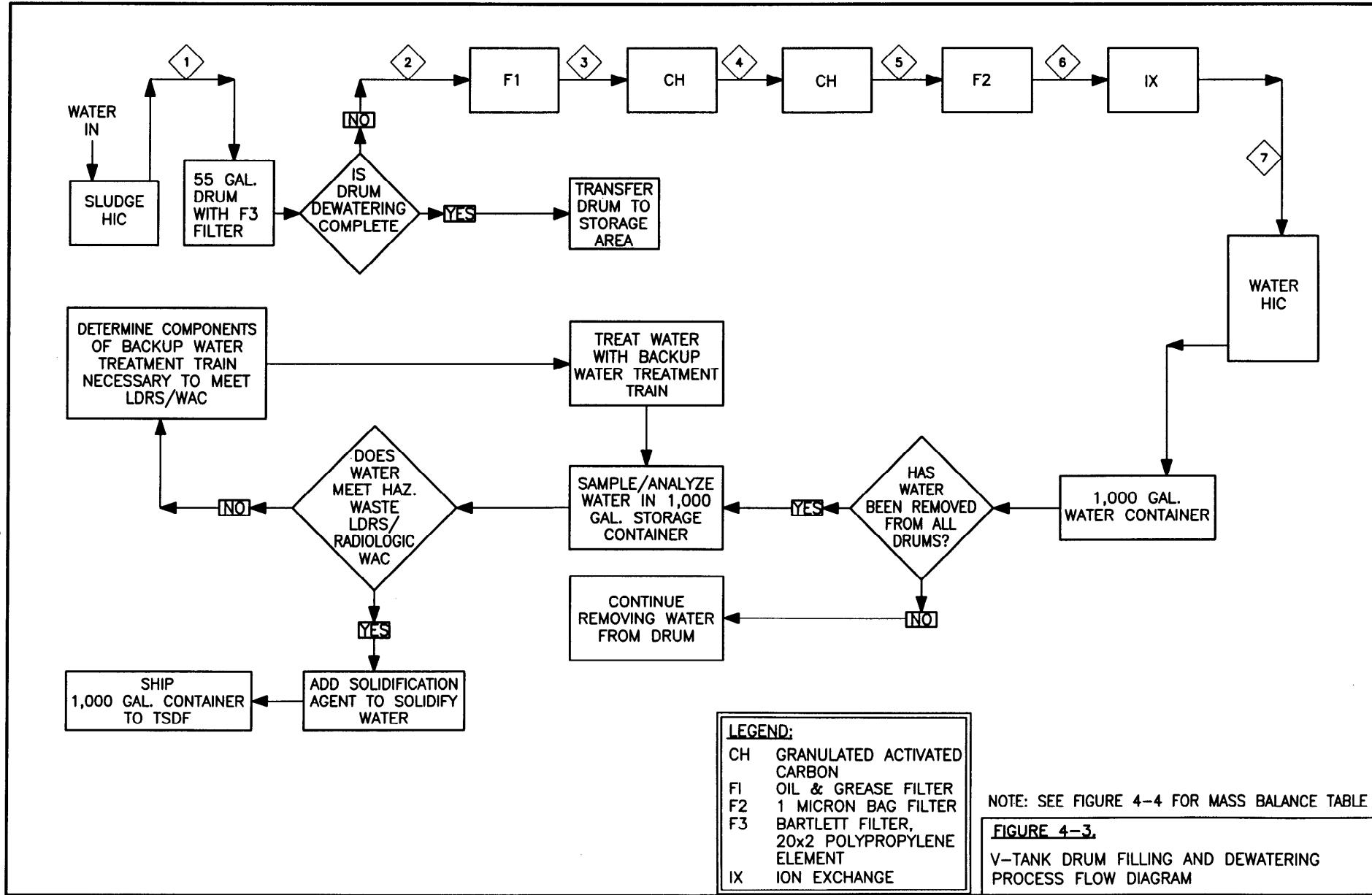
CH	GRANULATED ACTIVATED CARBON
F1	OIL & GREASE FILTER
F2	1 MICRON BAG FILTER
IX	ION EXCHANGE

NOTE: SEE FIGURE 4-1 FOR PROCESS FLOW DIAGRAM

FIGURE 4-2.

V-TANK SLUDGE REMOVAL/WATER TREATMENT
PROCESS FLOW MASS BALANCE TABLES

24/27



DRUM DEWATERING COMPOSITE MASS BALANCE							
STREAM NO.	1	2	3	4	5	6	7
STREAM DESCRIPTION	F3	F1	CH	CH	F2	IX FEED	WATER HIC FEED
FLOW RATE GPM	10	10	10	10	10	10	10
VOLUME, GAL	3706	1763	1763	1763	1763	1763	1763
LEAD mg/L	0.317	0.317	0.317	0.317	0.317	0.317	0.018
MERCURY mg/L	0.152	0.152	0.152	0.152	0.152	0.152	0.008
NICKEL mg/L	1.194	1.194	1.194	1.194	1.194	1.194	0.060
CADMUM mg/L	0.132	0.132	0.132	0.132	0.132	0.132	0.007
TETRACHLOROETHENE mg/L	0.039	0.039	< 0.01	< 0.01	< 0.01	< 0.01	0.056
TRICHLOROETHENE mg/L	35.602	35.602	35.602	1.80	< 0.05	< 0.05	< 0.05
METHYLENE CHLORIDE mg/L	5.008	5.008	5.008	0.25	< 0.01	< 0.01	< 0.01
1, 1, 1-TRICHLORETHANE mg/L	5.095	5.095	5.095	0.25	< 0.01	< 0.01	< 0.01
3, 3-DICHLOROBENZIDENE mg/L	0.0057	0.0057	0.0057	< 0.01	< 0.01	< 0.01	0.055
2, 4-DIMETHYLPHENOL mg/L	0.0068	0.0068	0.0068	< 0.01	< 0.01	< 0.01	0.036
INDENO mg/L	0.0031	0.0031	0.0031	< 0.01	< 0.01	< 0.01	0.0055
2-METHYLPHENOL mg/L	0.0717	0.0717	0.0717	< 0.01	< 0.01	< 0.01	0.11
4-METHYLPHENOL mg/L	0.0717	0.0717	0.0717	< 0.01	< 0.01	< 0.01	0.77
PHENOL mg/L	0.0087	0.0087	0.0087	< 0.01	< 0.01	< 0.01	0.039
TOC mg/L	85	85	85	4	< 0.5	< 0.5	< 0.5
Sr-90 pCi/L	1.341 E + 07	6.70 E + 06	6.70 E + 05				
Cs-137 pCi/L	7.369 E + 06	6.13 E + 05					
OIL & GREASE mg/L	2.96	2.98	1.00	< 0.1	< 0.1	< 0.1	< 0.1
TOTAL SUSPENDED SOLIDS mg/L	-	32.1	1	< 1	< 1	< 1	< 1
SPECIFIC GRAVITY	1.02	1.00	1.00	1.00	1.00	1.00	1.00

LEGEND:

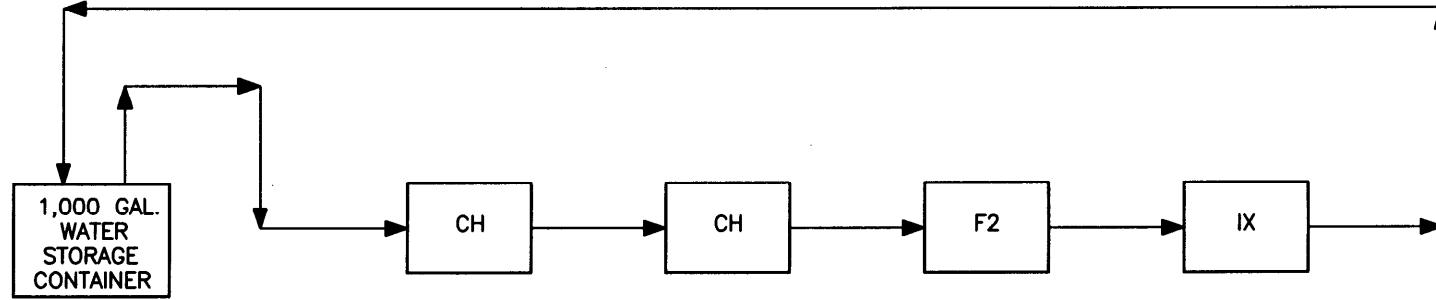
CH GRANULATED ACTIVATED CARBON
 F1 OIL & GREASE FILTER
 F2 1 MICRON BAG FILTER
 F3 BARTLETT FILTER,
 20x2 POLYPROPYLENE ELEMENT
 IX ION EXCHANGE

NOTE: SEE FIGURE 4-3 FOR PROCESS FLOW DIAGRAM

FIGURE 4-4.

V-TANK DRUM FILLING AND DEWATERING PROCESS FLOW COMPOSITE MASS BALANCE TABLE

26/27



LEGEND:

CH GRANULATED ACTIVATED
CARBON

F2 1 MICRON BAG FILTER

IX ION EXCHANGE

FIGURE 4-5

V-TANK BACKUP WATER TREATMENT
PROCESS FLOW DIAGRAM

27/27